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Fig. 1. *Dudleya pachyphytum* at the type locality, with three other insular endemics: *Ferocactus chrysacanthus*, *Eriogonum molle*, and *Harfordia fruticosa*. MB photo.

DUDLEYA PACHYPHYTUM, OF ISLA CEDROS, MEXICO

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Isla Cedros is the largest of the Pacific islands of Baja California. It is a rugged mountainous island of 134 square miles, lying halfway down the west coast, just off the broad hook that marks the widest part of the peninsula. It is a continental island, separated by a shallow 14-mile channel from this nearest mainland point, and is 7 miles from Isla Natividad to the south. Isla Cedros is 23 miles long from north to south and 11 miles wide at the wider south end. The northern part is a steep, narrow north-south range with peaks of 2000 to 3400 feet. The highest peak of the island, a quarter of the way from the south end, is 3950-foot Cerro Cedros. On the eastern shore at the base of this peak, and drawing water from its springs, is Cedros village, center for the local fishing industry.

A reconnaissance of the geology of Isla Cedros (Kilmer 1977) shows that the island was formed by an uplift of late Jurassic metamorphic and igneous rocks at a point where the Pacific plate was subducted beneath the western margin of the North American plate. Probably the island reached its present elevation in late Pliocene or earliest Pleistocene and so has been above water since then. These rocks may have a strong relationship to the Franciscan Formation, the basement rocks of the central and southern Californian coast and offlying islands. The possible geological relationship of Isla Cedros with insular Alta California gives emphasis

to the relationship between the small but striking relictual elements of the floras of the two areas.

Most parts of the island have a low rainfall: an 8-year mean for the village is 65.5 mm (about 2.5 inches). Consequently, most parts of the island, from shore to summit, have only a sparse desert scrub much like that of desert parts of the peninsula. According to Hale (1941), about 97 percent of the area is desertic. The most striking and conspicuous desert plants are copalquín or elephant tree (*Pachycormus discolor* var. *veatchiana* (Kell.) Gentry) mezcal or century plant (*Agave sebastiana* Greene), and a white-woolly, bush sunflower (*Viguiera lanata* (Kell.) A. Gray). Three little cacti, cardón (*Pachycereus pringlei* (S. Wats.) Britt. & Rose), garambullo (*Lophocereus schottii* (Engelm.) Britt. & Rose), and pitaya agria (*Stenocereus gummosus*

Fig. 2. *Dudleya pachyphytum* flowering at the type locality, with *Ferocactus chrysacanthus*. MB photo.



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Fig. 3. Inflorescence of *D. pachyphytum* at the type locality. It's not upside down: the spreading stem is seen diagonally from above. RM photo.

Fig. 4. *Dudleya pachyphytum* flowering at the type locality, with *Echinocereus maritimus*, *Ambrosia camphorata*, and *Harfordia fruticosa*. RM photo.

(Engelm.) A.Gibs. & Horak), common and conspicuous desert plants are copalquín or elephant tree (*Pachycormus discolor* var. *veatchiana* (Kell.) Gentry), mezcal or century plant (*Agave sebastiana* Greene), and a white-woolly bush sunflower (*Viguiera lanata* (Kell.) A.Gray). Three large cacti, cardón (*Pachycereus pringlei* (S.Wats.) Britt. & Rose), garambullo (*Lophocereus schottii* (Engelm.) Britt. & Rose), and pitaya agria (*Stenocereus gummosus* (Engelm.) A.Gibs. & Horak), common and conspicuous on many parts of the peninsula, are relatively scarce on the island. Smaller cacti are common, including a biznaga or barrel cactus (*Ferocactus chrysacanthus* (Orcutt) Britt. & Rose), with either red spines and red flowers or yellow spines and yellow flowers, and a "biznaguita" (*Mammillaria pondii* Greene), with bright red flowers. A cholla (*Opuntia prolifera* Engelm.) is abundant locally on the east coast, and a tuna or



prickly pear (*O. oricola* Philbrick) is scattered over the island.

Higher parts of the island presumably have more rainfall; and in some places frequent fogs bring more moisture. Hence at higher elevations the desert scrub in some areas gives place to more mesic vegetation, notably to sage scrub, chaparral, and even pine forest—vegetation types better developed in northwest Baja California and in Alta California. The most remarkable departure from desert vegetation is forest of *Pinus radiata* ssp. *cedrosensis* (J.T.Howell) Nemo (see Libby *et al.* 1968). The pines grow on north- to west-facing slopes, mostly at 1200–2000 feet elevation, in several groves at the north end and in others near the middle of the island. Each grove is exactly where a



Fig. 5. Pico Punta Norte in the fog, from the head of Arroyo de la Mina. In foreground: *Pinus radiata* *cedrosensis*, *Eriogonum molle*, *Malosma laurina*, *Agave sebastiana*.

bank or patch of fog regularly rests; and from fog, moisture condenses on the pine needles and drips to the ground like light rain, giving the moisture supplement the pines need to grow there. If the pines weren't there to condense the moisture, presumably the ground would be too dry for pines; so it is fortunate for the pines that they are there to perform this necessary function. Otherwise, they couldn't grow there.

Because of its accessibility by ship, Isla Cedros in the past century became better known botanically than most nearby parts of the peninsula, particularly mountainous parts. The known flora of the island now includes 245 vascular plants, about 216 native and 29 introduced. New weeds doubtless will continue to arrive; and since some plants are very local and some of these may be ephemeral or otherwise inconspicuous, further exploration very likely will add at least a few more natives.

Dudleya is well represented, and still puzzling, on Isla Cedros. Diploid *D. acuminata* Rose, with mainly solitary sessile rosettes of flat acuminate leaves and with yellow flowers, is occasional on slopes and ridgetops at middle elevations. The variable polyploid *D. albiflora* Rose, with clustered rosettes of thick, narrow, acuminate leaves and with white flowers, is more widespread, from shore to pines and almost the length of the island. Another variable polyploid complex, still not understood, occurs from the eastside canyons to the pines, with small to large, solitary or mostly clustered rosettes of flattish, acute leaves and with pink flowers. Although some additions to the flora are to be expected, it is most surprising now to add the striking new *D. pachyphytum* Moran & Benedict, which is not only distinctive but also conspicuous and abundant, even predominant, in its area. Its clustered rosettes, in contrast to other Cedros species, have massive blunt farinose leaves; the flowers are white. It has been overlooked probably because it occurs only at the rather inaccessible and little-visited northern tip of the island, out of easy reach by botanists.

In March 1971 Benedict found a single uprooted rosette of an unknown *dudleya* in the upper part of Cañada de la Mina¹—which empties on the east coast at the small lighthouse 2 miles from the north end. Returning in February 1975, he found many of the plants on seacliffs and under the pines both west and north of Cañada de la Mina, though he saw no more in that drainage. In June 1977 he found plants nearly ready to flower and brought some back to flower in Santa Barbara. Cañada de la Mina has become a favorite stop for commercial natural history trips and so has had many recent visitors, botanical and otherwise; and several plants of the

dudleya have found their way back to Moran—from Margie Stinson in 1976, from George Hale in 1979, and from Reed Pierce in 1979. Also, we hear that several other visitors have found it. With the arrival of the September-October *Cactus and Succulent Journal*, we fished our manuscript out of the mailbox and tacked on this sentence to say that Lau (1980) told of finding the *dudleya* in November 1977 and showed four handsome color photographs of it.

From July 17th to 21st of 1980, with Michael Astone, we visited Isla Cedros to study, photograph, and collect the *dudleya* in flower and to learn more about its distribution. We climbed from Cañada de la Mina and followed the precarious main ridge to Pico Punta Norte at the extreme north end of the island, examining plants along the way and scanning cliffs and slopes below with binoculars. We found the plant abundant and in good flower on the west flank of the island and on the slopes of Arroyo Valdez, the east-draining canyon just north of Cañada de la Mina: here in its real homeland it is as abundant as any *dudleya* we know of, often dominating the steep slopes. Now we are able to give a full account of the plant and its habitat.

North of Cañada de la Mina some peaks and ridges are capped by a narrow mantle of ancient soil with enough permanence to support pine forest. This soil, and so the forest itself, is eroding at the lower edge and slowly slipping downward to form a broad steep deposit of boulders, talus, and dead tree trunks. The precipitous slopes below have broad boulder-clogged canyons and steep talus slopes plunging dramatically to the sea. The actively moving talus is nearly bare of plants, though occasional outcrops of bedrock support islands of vegetation.

Seaward slopes at the north end are dominated by cool northwest winds, often saturated with moisture, blowing almost incessantly from the open ocean. On the windward side of the ridges, air temperature is often so close to the dew point that slight changes in temperature cause frequent dramatic changes, from clear bright sunshine to dense dripping fog. In the lower and middle part of the forest belt this change can occur several times an hour. In the lower reaches of the forest and on the more exposed windward bluffs, the contest between clear air and fog is seldom resolved, and during daylight an almost perpetual bright mist prevails. Since the fog extends only up to the crest of the ridges, the fog layer is never very thick, and usually a large amount of lumination penetrates to the ground.

Commonly about an hour before sunset the fog layer comes in and completely enshrouds the windward slopes until the middle of the following morning. During the night and foggy periods of the day, the pines, with their large condensing surfaces, irrigate themselves and their associates extensively, probably in excess of rainfall. The pine

¹Named for a copper mine run by American George Brown from ca. 1905 to 1914. Contrary to any fictional account you may have read, the mining operation was not secret from the Mexican government.

duff is saturated beneath the top three inches.

Dudleya pachyphytum occurs sparingly in the pine forest and abundantly on cliffs and talus in the fog zone. The floor of the forest is thickly carpeted with pine needles, and exposed boulders are densely covered with lichens. There is an understory of a few scattered shrubs of species that occur also outside the forest. Here the dudleya is widely scattered, usually at the base of a boulder or in a pocket of soil in a rock crevice or occasionally in the pine duff. Seedlings and young plants are frequent in the forest as well as outside. The rare pocket of soil free of duff may have five to ten seedlings. Thus the shaded forest floor is a nursery where conditions seem good for germination and establishment. But although the plants grow large enough to flower, only solitary rosettes were seen and no old branching plants.

Outside the forest, the vegetation changes dramatically to the open low maritime desert scrub typical of the island. Most conspicuous and characteristic is the handsome large gray *Agave sebastiana*, not only on stable substrates but also on talus fields—one of few plants to gain a roothold there. Also very conspicuous is the large bushy white *Eriogonum molle* Greene, endemic to the north end, growing best on rocky substrates at the edge of the forest. *Viguiera lanata* Kell., perhaps the widest spread perennial on the island, is an aggressive colonizer able to establish in precarious situations such as steep loose unstable soil.

Away from the influence of the pines, the desert plants have to rely on their own varying abilities to feed on the fog. Permanent rock surfaces are thickly covered with lichens, sustained by the fog. The heavily glaucous leaves of the dudleya, and likewise of the agave, provide a non-wettable condensing surface from which droplets run to the base. In the mornings, an accumulation of moisture can be seen within the rosette and about the base of the plant.

Dudleya pachyphytum is most abundant and best developed on exposed rocky cliffs and steep slopes outside the forest. Here it forms clumps of 10 to 20 or even 50 or more rosettes. It also extends down slope at least to the lower edge of the fog belt, at about 300 feet, on talus as well as on stable rock. Like the agave, ferocactus, and mammillaria, it survives on talus partly because it is a successful roller: uprooted plants may roll with the rocks but reestablish themselves below. Far below the pines, on the lower reaches of the talus slopes, on recently exposed canyon walls, and on the upper faces of the highest sea cliffs, the dudleya forms a unique association with *Viguiera lanata*. The hundreds of scattered brilliant white dots of the two plants contrast strikingly with the dull gray and black walls of the huge cliffs and canyons. These and the stark white splotches of hundreds of pelican roosts, in the huge scale of the landscape, create an edge-of-the-world scene that is utterly awesome.

***Dudleya pachyphytum* Moran & Benedict,**
Phytologia 47:85. 1980.

Plants to 7 dm or more wide, of 10–20 or sometimes 50 or more rosettes. Caudex to 4 dm or more long, in age decumbent, 2–5 cm thick, densely clothed below with persistent dry leaves and with these ca. 10 cm thick. Rosettes compact, 12–22 (–33) cm wide, of 12–25 (–35) leaves or to 55 in cultivated plants. Rosette leaves farinose, often pale orange in age, massive and turgid but drying tough and leathery, ovate to oblong, broadest near base, rounded to broadly obtuse, apiculate, 5–10 (–13) cm long, 3–5 (–7) cm wide, 1.5–2.5 cm thick, ventrally flattish with conspicuous pattern of low ridges corresponding to edges of leaves adjacent in bud, dorsally rounded and asymmetrically low-keeled, the margins obtuse near base to rounded above. Floral stems 1–4, erect or mostly spreading, 2–5 (–7) dm long, 5–12 mm thick and to 18 mm wide at base, farinose, pale pink becoming red especially below, with 20–35 (–50) spreading leaves; these cordate-ovate, clasping, broadly acute, 1–2.5 cm long and wide, 3–13 mm thick. Inflorescence nodding in bud, later erect, rather dense, 8–14 cm wide, of 3–6 close-set 1–2x bifurcate branches or sometimes with a few more scattered below; cininni circinate, in age spreading, 2–5 cm long, with 5–12 flowers; pedicels erect, 2–6 mm long; 1–2.5 mm thick at base, thickened upward. Calyx rounded below, 5–9 mm long, 4.5–7 mm wide, the segments appressed, triangular-lanceolate, acute, 4–7 mm long, 2.5–4 mm wide. Corolla white, 8–11 mm long, 4–5 mm thick, the petals connate 2–3 mm, erect or with tips slightly outcurved, elliptic-oblong, acute, 2–3 mm wide. Filaments white, the epipetalous 5–8 mm long, adnate 2.5–3.5 mm, the antesealous 6.5–9 mm long, adnate 1.5–2 mm; anthers before dehiscence red, 1.2–1.4 mm long. Nectar glands white, 0.9–1.2 mm wide. Gynoecium 7–10 mm high, 2–3 mm thick, the pistils erect, appressed, connate ca. 2 mm ventrally, tapering into styles ca. 1.5–2 mm long; ovules 25–45, 0.4–0.5 mm long. Seeds ca. 0.6 mm long, with ca. 15 longitudinal striations. Chromosome number: $n=17$.

TYPE COLLECTION: Abundant on upper west slope of the island at 450 m, ca. 1 km northwest of the old mine area of Cañada de la Mina, north end of Isla Cedros, Baja California Norte, México (near 28°21' 1/2"N, 115°14'W), 18 July 1980, *Moran & Benedict* 29036: holotype SD 105549; isotypes SBBG and to go.

DISTRIBUTION: Known only from the north end of Isla Cedros at ca. 100–500 m elevation, occasional in the pine forest and abundant on cliffs and steep rocky slopes in the fog zone, especially with north to northwest exposure: from Punta Norte at least 3 km south on the west flank of the island, apparently down to ca. 100 m; around the upper watershed of Arroyo Valdez (south to SE of Punta Norte) and to



Fig. 6. Pines and fog at Pico Punta Norte.

the crest of the divide with Cañada de la Mina to the south; very scarce in upper Cañada de la Mina, down to ca. 300 m. The few solitary young rosettes seen on the upper slopes of Cañada de la Mina, where none were noted before, raise the question whether the range could be expanding southward.

In June 1977 about half the plants seen were preparing to flower and in July 1980 about half were flowering, each time with all inflorescences at about the same stage. Though some flowering plants bore remnants of old floral stems, few of these were intact as if from the year before. On the other hand, most mature plants not flowering bore intact dried inflorescences evidently from the year before. Thus it appeared that most plants were not flowering in consecutive years.

The rosettes and stems of the dudleya are attacked by the larva of some unidentified insect and the inflorescence by the larva of the Sonoran blue butterfly (*Philotes sonoriensis* (Felder & Felder)). We noted that many developing floral stems had been nipped off, presumably by the Cedros Island black-tailed deer (*Odocoileus hemionus cerrosensis* Merriam); we saw two of the deer at Pico Punta Norte.

In cultivation the leaves may become more numerous, less farinose, and longer, so that the rosette looks less compact. One plant grown for six years in Santa Barbara had a rosette of about 55 leaves—when a thief interrupted the study.

The erect petals and pistils place *D. pachyphytum* in the subgenus DUDLEYA. From buds of the type collection Dr. Charles H. Uhl reports some irregularity in meiosis, with extra and undersized microspores. He was unable to get an

exact chromosome count but guessed $n=17$. However, from a plant collected by Benedict in 1977 Dr. Uhl reports a definite count of $n=17$, with no irregularity. This is the basic number for the genus (Uhl & Moran 1953); thus this species is a diploid.

In its habit, with clusters of rosettes on elongate stems, *D. pachyphytum* recalls such other maritime species as the diploid *D. candida* Britt. and *D. farinosa* (Lindl.) Britt. & Rose and the polyploid *D. caespitosa* (Haw.) Britt. & Rose and *D. greenii* Rose—which often likewise have farinose leaves. However, it differs from these, and seems unique in the genus, in its blunt and very thick leaves. The rosettes thus recall those of some members of the Mexican genus *Pachyphytum*, for which we name it. The undistinguished white flowers are rather similar to those of the variable polyploid *D. albiflora* Rose, which also occurs on Isla Cedros (and southward). That plant is much smaller, with smaller and especially narrower leaves, which are acuminate to slender-acute.

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